FACTS
FOR ENVIRONMENTAL STUDIES

Ontario Ministry of the Environment

SET 7

ACID RAIN

AIR POLLUTION AND PLANTS

EXAMINING PLANT DAMAGE

DEVELOPING ENVIRONMENTALLY AWARE CITIZENS

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EDUCATIONAL RESOURCES CO-ORDINATOR
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135 ST. CLAIR AVENUE WEST
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FACTS

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Ministry of the Environment
Ontario

ACID RAIN

Today it is almost impossible to pick up a newspaper without reading something about acid rain.

Yet the problem wasn't really brought to public attention until 1971 when it was announced at the Stockholm Conference on the Environment that acid precipitation in Sweden appeared to be affecting reproduction in fish populations. Later studies showed a similar problem in other parts of the world as well as Canada.

While all rainfall is slightly acidic due to carbon dioxide, which occurs naturally in the atmosphere, precipitation in recent years is becoming more acidified due to the presence of sulphur and nitrogen oxides.

The oxides of sulphur are discharged into the atmosphere through the burning of fossil fuels. Factories and power plants are the worst culprits. In the atmosphere the sulphur oxides - in the presence of air moisture - are converted into sulphuric acid. The acid is then carried back to the Earth as rain and snow.

The nitric acid process begins when automobile owners turn the ignition key, for most nitrogen oxides in the atmosphere are produced by the burning of gasoline.

Since the greater part of the world is dependent upon fossil fuel, it's not surprising that acid rain is a world-wide problem.

Effects of Acid Rain

Although acid rain does not directly harm man, it changes the acid-alkali balance in lake and river water and, as a result, threatens fish life.

In the spring, snow which has piled up over the winter melts and flows into lakes and rivers. This run-off occurs at the same time as sensitive life changes are taking place in many fish species and aquatic life. If the snow contained large concentrations of pollutants, fish are exposed to the worst possible water quality conditions at their sensitive stages.

Specific effects includes: failure to reproduce successfully, deformation of adult fish and serious changes in population structures.

Some observations also suggest that the uptake of mercury by fish is promoted by acidic conditions, although the phenomenon is not well documented or understood.

In the extreme, fish populations get older with fewer and fewer young fish. Within a few years, if nothing changes, the lake or river is barren of fish life. It is called a dead lake.

Further research also links acid precipitation with reduced growth of forests, poor croplands and the deterioration of many buildings such as the Taj Mahal.

In Ontario, at least 140 lakes appear to be affected and are unable to support a sports fish population. A further 48,000 lakes are projected to go the same way over the next two decades unless something is done on an international scale.

The areas of the province most susceptible to acid rain are principally the Central, Northwestern and parts of Northeastern Ontario because of their limited watershed buffering capacities. The buffering capacity is related to local geology, with areas dominated by granite being most susceptible.

This is one of the reasons why many lakes in the Sudbury area lack fish. This is also the reason why many recreational lakes in Muskoka-Haliburton will lose their fisheries if no action is taken.

Solutions

It seems logical to suggest that if we cut back our emissions of sulphur and nitrogen compounds, then the levels of acidic rain would be reduced. However, if we eliminated every Ontario source of sulphur and nitrogen oxides, it would have almost no impact on the continuing damage to our lakes. Ontario produces less than three million tons of these oxides, compared to a total of 39 million tons in the Northeastern U.S.

Moreover, as things now stand, we can expect more use of fossil fuels, as oil conservation programs in the U.S. promote the conversion of gas and oil in utility plants to coal.

As part of the solution, scientists, have conducted experiments on the use of lime in severely affected areas to improve a lake's capacity to buffer against acid levels. However, this is regarded temporary and undesirable stop-gap measure.

Sweden has had to give up its policy of seeking abatement at an international level in Europe and has undertaken a liming program covering some 500 lakes.

To find out more about what the Ontario Ministry of the Environment is doing about acid precipitation, write:

Information Services Branch,
Ministry of the Environment,
6th Floor,
135 St. Clair Avenue West,
Toronto, Ontario
M4V 1P5

Experiment: To sample for acid rain.

Materials: short, wide jars with lids
maps of your town or city
test tubes and stoppers
waterproof markers
pH test paper with colour comparison charts

Methods:

1. Mark the locations of factories and power plants on the maps.
2. Choose the locations for the sampling jars, taking into consideration the need for rain to fall directly into the jars, the possibility

that the jars will be disturbed, the direction of prevailing winds, etc.

3. It is best to place the jars out just before a rain.
4. Add the rainwater to a test tube containing a piece of pH paper. Shake the tube for about a minute.
5. Compare the colour of the test strip with those on the colour comparison chart.
6. If there are any ponds or lakes nearby, you may try sampling these waters.

NOTE: Normal rainfall, will have a pH of about 5.6 or greater - just slightly on the acidic side of neutral pH 7.

Questions:

1. On which areas of your town or city have higher levels of acid precipitation fallen?

2. Does the existing weather pattern influence the distribution of acid rain?

3. How doe the pH values of rain and/or groundwater samples compare to those of familiar substances such as vinegar, soda water, baking soda and household ammonia?

4. Consider the economic reprecussions of acid rain?

FACTS FOR ENVIRONMENTAL STUDIES

Ontario Ministry of the Environment

AIR POLLUTION AND PLANTS

Pollutants in the air can damage vegetation, endanger human and animal health, accelerate the deterioration of buildings and clothing, reduce visibility and generally interfere with our enjoyment of the outdoors.

Damage to plant life is an area of particular concern. Air pollutants can cause visible marks on leaves, reduce the growth and yields of plants and even cause death. Such injury to horticultural crops, for example lettuce or tobacco, can result in serious economic problems.

Sources of Air Pollution

In Ontario, air pollutants which cause injury to plants are classed as either local or widespread.

Local pollutants are those that are emitted from a specific stationary source. The vegetation injury occurs in a well defined zone.

Local pollutants are usually 1) sulphur dioxide, 2) flourides, and 3) particulate matter.

Widespread pollutants are generally referred to as "oxidants". These are produced in the atmosphere during a complex reaction involving nitrogen oxides and reactive hydrocarbons - the main components of automobile exhausts. (As the reaction takes place in the presence of sunlight it is referred to as a photochemical reaction.) The vegetation damage from oxidant buildups in the air can occur over vast areas covering hundreds of miles.

1. Sulphur Dioxide

Major sources of sulphur dioxide are coal-burning operations, especially those providing electric power and space heating. They can also result from the burning of petroleum and the smelting of sulphur-containing ores.

A. Acute injury is caused by the absorption of high concentrations of sulphur dioxide in a short time.

   The symptoms appear as lesions (small injuries) which occur between the veins and occasionally along the

leaves. The colour of the affected area can vary from a light tan or near white to an orange-red or brown, depending upon the time of year, the type of plant and weather conditions.

B. Chronic injury is caused by long-term absorption of sulphur dioxide at low concentrations. The symptoms appear as a yellowing of the leaf, and occasionally as a bronzing on the undersurface.

The following plants are considered susceptible to sulphur dioxide: alfalfa, barley, buckwheat, clover, oats, rhubarb, spinach, squash, Swiss chard and tobacco.

2. Fluorides

Fluorides are emitted into the atmosphere from the combustion of coal: the production of brick, tile, enamel frit, ceramics, and glass; the manufacture of aluminum and steel; and the production of hydrofluoric acid, phosphate chemicals and fertilizers.

The damage caused by fluorides appears at the margins or tips of the plants. Little injury appears at the sites of absorption. The injury starts as a gray or light-green water-soaked lesion,

which turns tan to reddish brown. With continued exposure the damaged areas increase in size, spreading in or downward.

The following plant species are susceptible to fluoride damages: apricots, prunes, plums, grapes, gladiola, tulips, iris and sweet corn.

3. Particulate Matter

Particulate matter such as cement dust, magnesium-lime dust, and carbon soot, deposited on vegetation, can inhibit the normal respiration and photosynthesis mechanisms within the leaf.

4. Oxidants

Ozone and PAN (peroxyacetyl nitrate) are the main pollutants in smog.

Ozone symptoms usually occur on the upper surface of affected leaves and appear as a flecking, bronzing, or bleaching of the leaf tissues. PAN causes bronzing, silvering or glazing of lower leaf surfaces.

Ozone sensitive plants include bean, corn, onion, potato, radish, spinach, tobacco and tomato. Plants sensitive to PAN are bean, tomato, lettuce, Swiss chard and endive.

To find out what the Ontario Ministry of the Environment is doing about air pollution, send for their fact sheet entitled "How Air Pollution Affects Vegetation".

Write: Information Services Branch
Ministry of the Environment
6th Floor
135 St. Clair Aveneue West,
Toronto, Ontario
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Experiments:

1. Plant experiments are best done during the spring and summer.
2. Be sure to use plants that are healthy to begin with.
3. You may want to set some potted plants near a power plant, factory, or highway; or you may observe plant life growing near these sources of pollution.
4. Tobacco and spinach plants are especially sensitive to

photochemical oxidants.

If exposed to high concentrations, small dark dots, larger white spots and dead areas may appear on the top of the leaf, the bottom surface will be shiny.

5. Alfalfa, squash and carrot plants as well as the leaves of tomato and lettuce are reliable for monitoring sulphur dioxide in the air, the plants will turn yellow; if exposed to high levels, the leaves will collapse and become water-soaked.

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EXAMINING PLANT DAMAGE

Trying to evaluate the extent of plant damage by air pollutants is often difficult for a number of reasons: 1) personal judgements vary widely from person to person; 2) time of injury, maturity of the plant and other environmental conditions must be considered; and, 3) people vary in their opinions as to whether aesthetic losses should be considered as serious as economic losses.

The following guide is intended to provide a standardized system for evaluating vegetation injury.

Since air pollutants normally affect the foliage, we have dealt with this portion of the plant in detail.

The Structure of a Leaf

A leaf is an expanded outgrowth of the stem. In most cases, there is a flattened, green blade. The blade is attached to the stem by a stalk or petiole. The blade is strengthened by a number of ribs or veins which carry water, minerals and food through the leaf.

If you look at a cross section of a leaf under a microscope you will see three distinct kinds of tissue. The upper and lower surfaces are covered by an epidermis. Between these layers is the mesophyll, composed of several layers of cells.

Most of the movement of water vapour and other gases into and out of the leaf tissues occurs through the stomata. These are lens-shaped pores that perforate the epidermis and open into air spaces between cells of the mesophyll.

Air pollutants enter the plant through the stomata of the leaf. At present, their actions after they enter the leaf cells is not yet fully understood.

Leaf Injury

By careful observation of an injured leaf or plant, it is usually possible to be sure the injury is caused by a pollutant. Pollutants enter the plant through the stomata of the affected leaf.

Injuries to plants, which have been exposed to high concentrations of a pollutant, are generally evident within a few hours of exposure. Chronic injury following long periods of exposure to low concentrations of pollutants is more difficult to diagnose.

Glossary of Terms Used in Classifying Injury

I. LEAF

(a) Type of Injury

(i) Normal - healthy, green leaf

(ii) Necrotic - death and destruction of cells or tissues. Color may vary from ivory to tan, red, brown, or black.

(iii) Chlorotic - light green or yellowish color of leaf due to presence of less than normal amount of chlorophyll.

(iv) Mottle - green and chlorotic areas in the leaf giving it a spotty appearance

(v) Terminal - area restricted to tip of leaf or tips of lobed leaf

(vi) Marginal - area restricted to margin of leaf

(vii) Intercostal - area occuring between leaf veins

(viii) Acute - symptoms appearing very quickly, often within hours of fumigation

(ix) Chronic - injury developing slowly, over a long period of time

(b) Lesion Types (use hand lens for inspection)

(i)	Zonate	- necrotic area marked by tissue of a different color, as in successive injury where each margin of necrotic tissue remains visible.
(ii)	Banded	- similar to zonate but occuring on linear leaves such as conifer needles
(iii)	Coalescent	- lesions large or close enough to run together
(iv)	Fleck	- lesion not greater than 1-2mm diameter
(v)	Stipple	- has a "dot-like" appearance to the eye
(vi)	Bronzing	- shiny, brownish surface of leaf usually on one surface
(vii)	Bifacial	- injury to both surfaces of the leaf at the same location
(viii)	Anthocyanosis	- normal green leaf pigments partially or totally obscurred by excessive production of reddish pigments
(ix)	Shot hole	- hole left in a leaf after the necrotic tissue has broken away from the centre of a lesion

(c) Leaf Condition

(i)	Turgid	- normal leaf, swollen with internal water
(ii)	Flaccid	- wilted leaves, limp or flabby due to excessive loss of internal water
(iii)	Water Soaked	- early state of necrosis, tis-

		- sues appear wet inside leaf, or as "boiled leaves"
(iv)	Epinasty	- twisting of leaves, deformities in leaf shape, also refers to twisting of stems
(v)	Abscission	- act of cutting off part or entire leaves or parts of plant by physiological processes

II ROOTS

Condition of roots may be evaluated under the following categories:

(a) stubby, necrotic, discoloured

(b) presence or absence of root hairs

(c) lesions or crackling of root bark

(d) normal and abnormal nodules on roots

III PLANT CONDITION

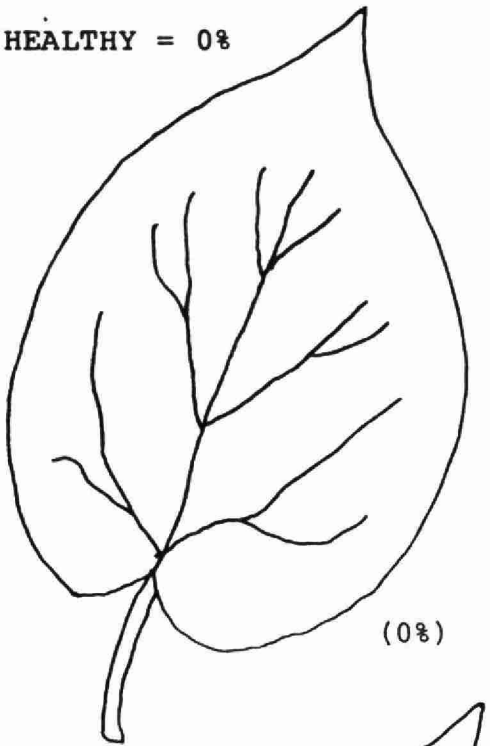
(i)	Vigorous	- healthy growth, robust
(ii)	Stunted	- dwarfed, less than normal growth
(iii)	Retarded	- apparently healthy but is behind normal plant in state of maturity
(iv)	Spindly	- long and slender, i.e. small leaves, long internodes.

LEAF INJURY RATING

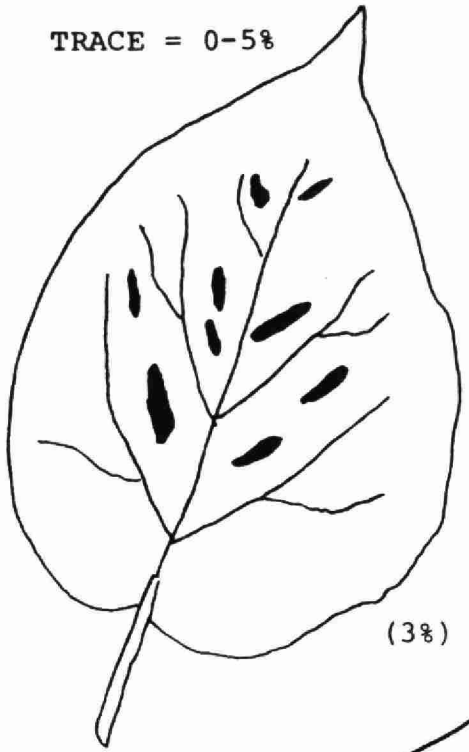
Rating	% of leaf surface affected
Healthy	0
Trace injury	>0 - 5
Light injury	6 - 15
Moderate injury	16 - 35
Severe injury	>35

(When rating fleck or stipple injury, evaluate the area which shows symptoms; do not attempt to calculate the precise area of the stipple or fleck).

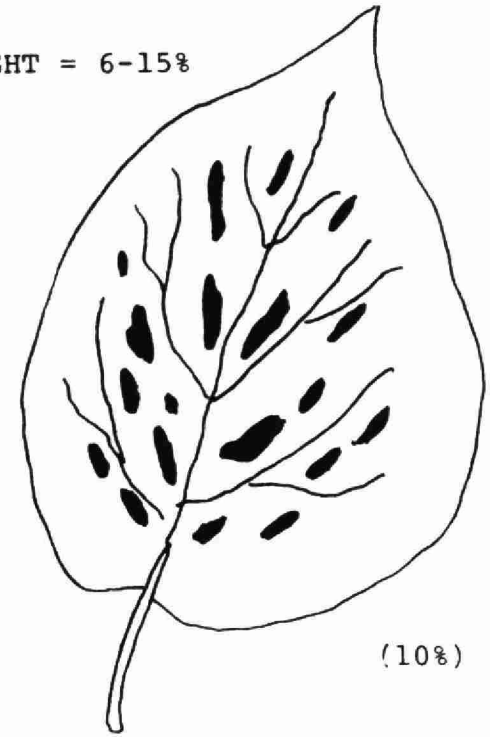
HEALTHY = 0%



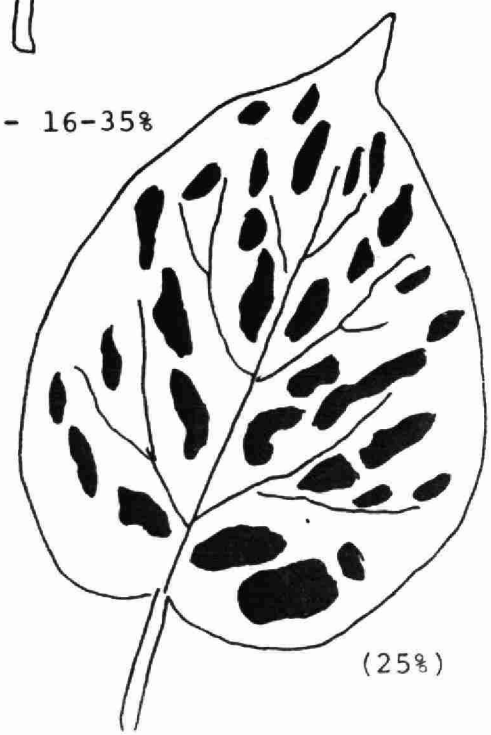
TRACE = 0-5%



LIGHT = 6-15%



MODERATE - 16-35%

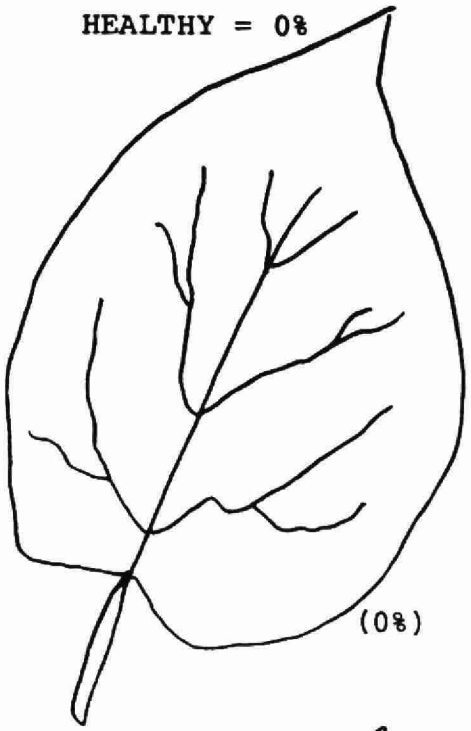


SEVERE = >35%

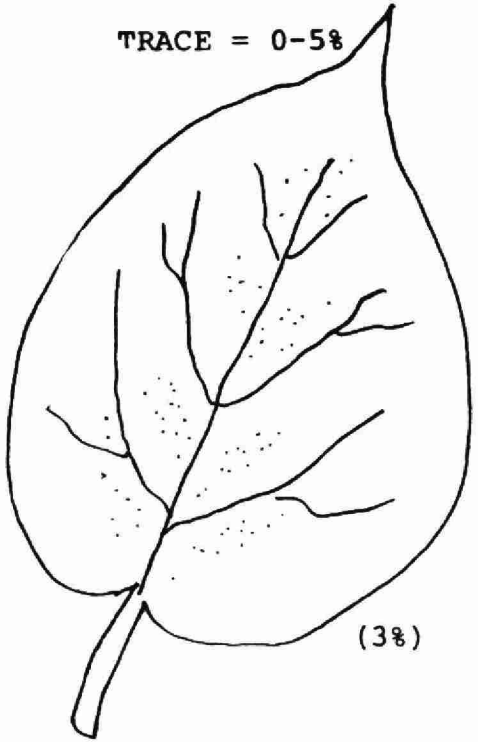
INTERCOSTAL TYPE OF INJURY

(area inside brackets is the amount of injury illustrated)

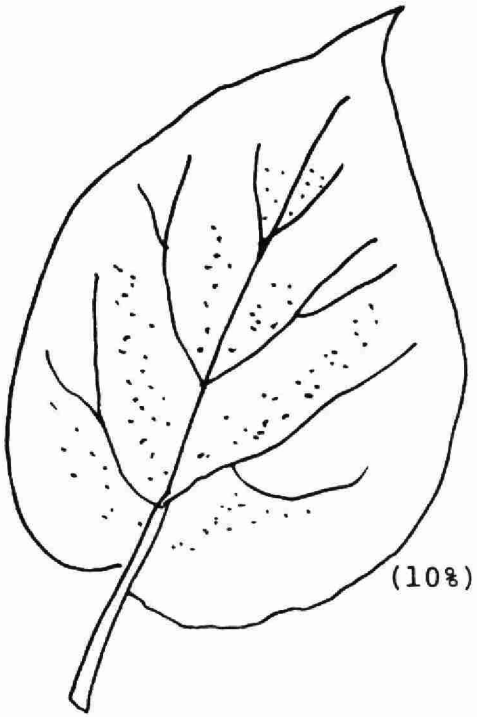
HEALTHY = 0%



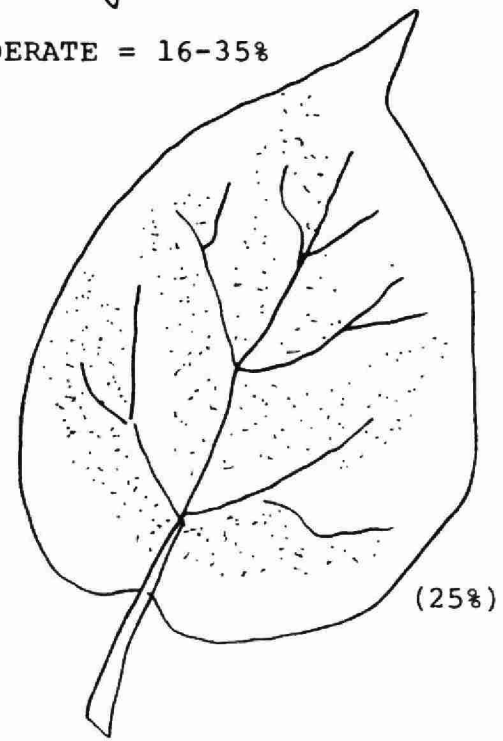
TRACE = 0-5%



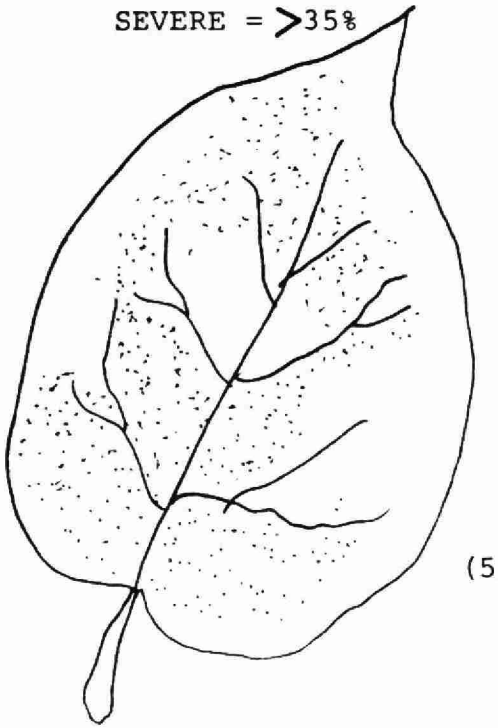
LIGHT = 6-15%



MODERATE = 16-35%



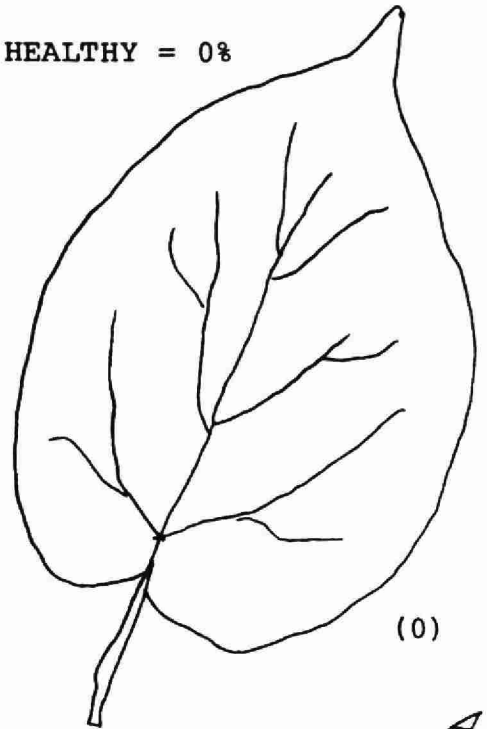
SEVERE = >35%



FLECK TYPE INJURY

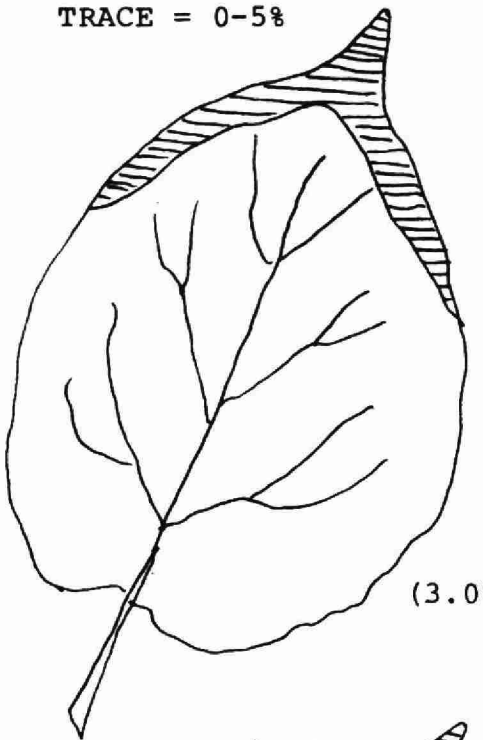
(area inside brackets is the amount of injury illustrated)

HEALTHY = 0%



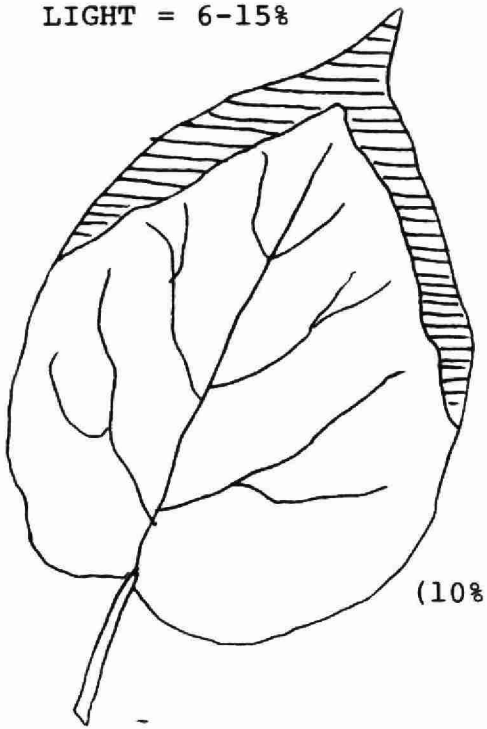
(0)

TRACE = 0-5%



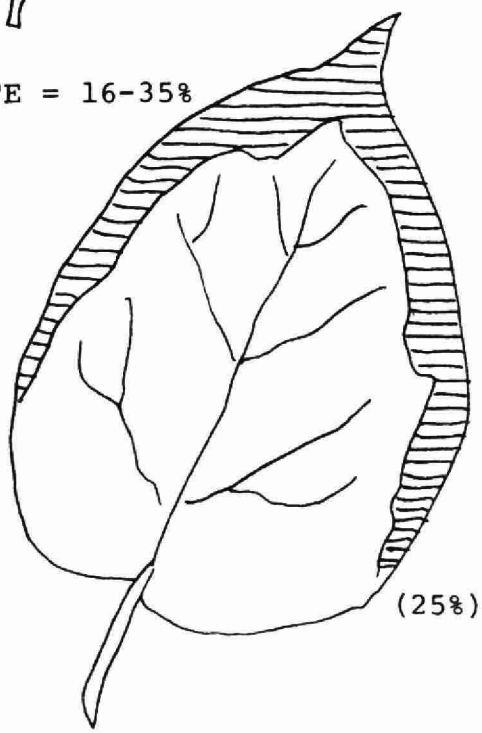
(3.0%)

LIGHT = 6-15%



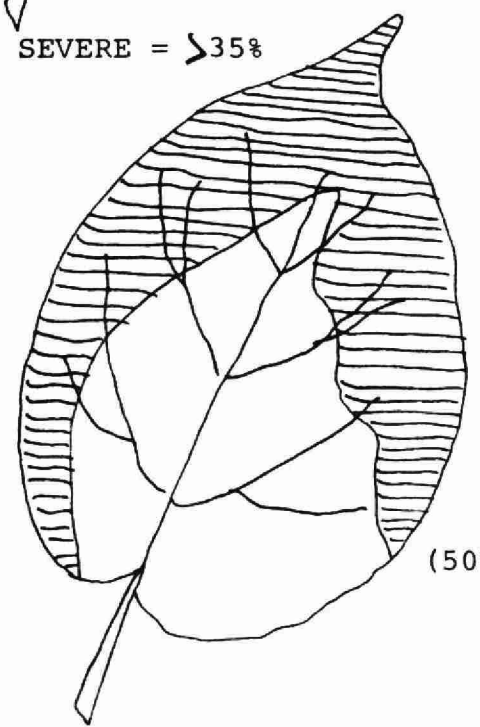
(10%)

MODERATE = 16-35%



(25%)

SEVERE = >35%

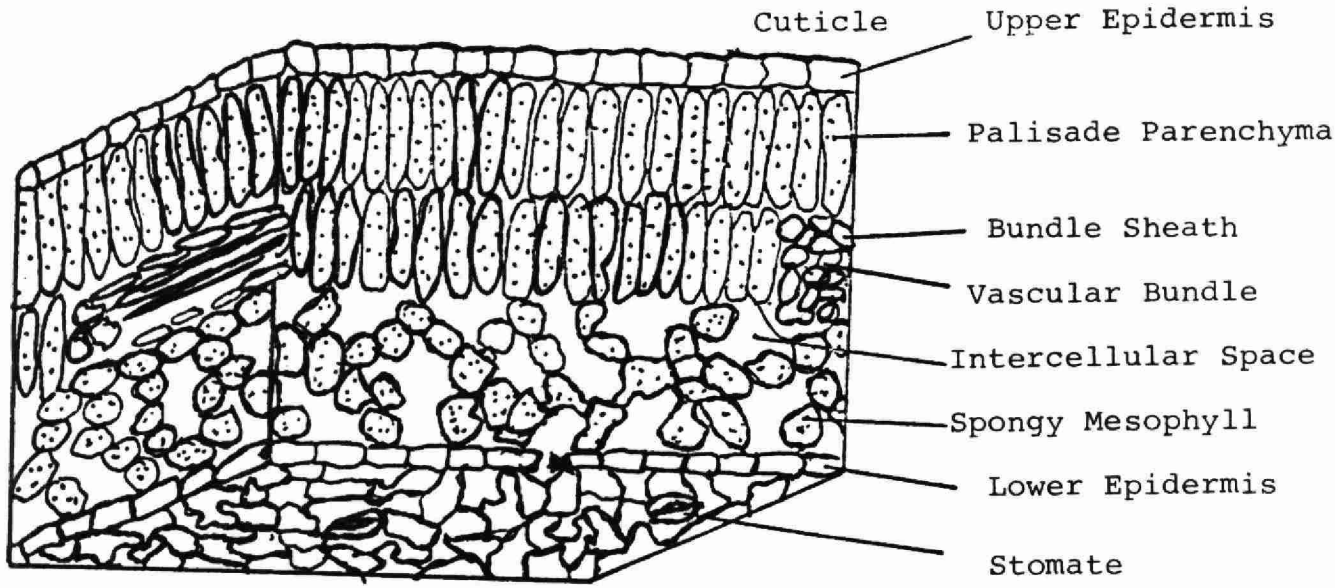


(50%)

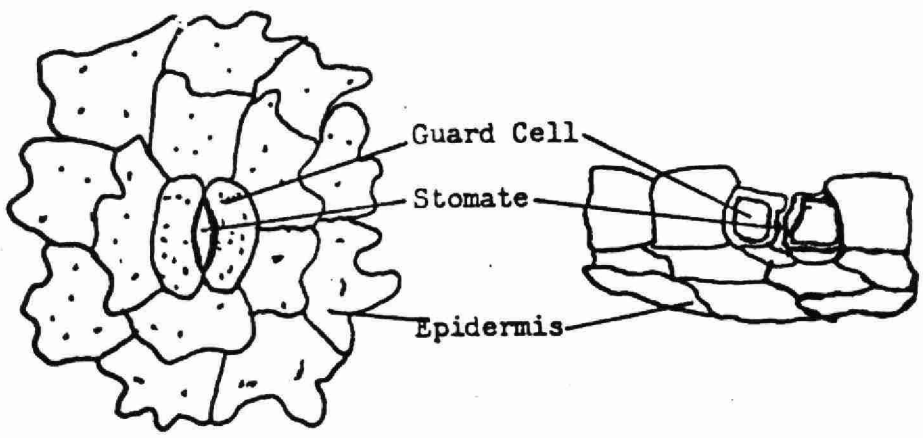
TERMINAL-MARGINAL TYPE OF INJURY

(area inside brackets is the amount of injury illustrated)

Figure 1. Diagram of section of typical leaf showing nature of cells and tissues.



Close-up of Stomate



Surface View

Cross-Section

FACTS FOR ENVIRONMENTAL STUDIES

Ontario Ministry of the Environment

DEVELOPING ENVIRONMENTALLY AWARE CITIZENS

Everyday each of us is directly involved in environmental problems and decisions. Whether these day to day activities of ours are to the benefit or detriment of our life supporting environment is far too often a matter of pure chance. Most often we are totally unaware of the fact that we are even making a decision that affects the environment.

Many of these decisions involve actions so mundane that they are undertaken almost unconsciously. They seldom receive much, if any, consideration as to their implications for the health of the environment. Yet it is our environment that provides us with the materials necessary for our basic needs and desires. Abuse of the environment is brought about by far more than the actions of a few callous industrial complexes; it is the cumulative effect of all the "little" things done by each and every one of us.

Let's examine very briefly some of the aspects of regular living where questions arise that affect the quality of the environment and thus its ability to provide for basic human needs and wants. Hardly exhaustive, in fact barely an introduction, the following list is merely illustrative and suggestive of others.

Family life affects the environment. How big a family will you have? What demands will each new member make on the world's supply of food and other natural resources? Most of a child's attitudes are formed by the time he reaches school; what will you have taught your child about the world by that time? Will he have learned to respect or defile the environment? How do the families' recreational activities affect the environment and vice versa? Do you treat most material things as expendable or reusable?

A person's work affects the environment. If a businessman, do your business costs include a legitimate figure for pollution abatement? Do you practice conservation at home, while condoning exploitive practices abroad to secure raw materials? Do you support conservation groups in your community? If a worker, does your union, with your help, work as hard for correcting any of the companies' anti-environmental activities as for fringe benefits?

The market place produces opportunities for a host of environmental decisions by you as a consumer. What products will you buy? What products will you not buy? What natural resources do these purchases and non-purchases represent? Will you choose a synthetic made of non-renewable resources or a similar product produced from renewable resources? Will you contribute to the decline of a rare animal species by buying a coat made

of its fur; or will you buy a less prestigious imitation fur? What is your attitude towards packaging and its attendant solid waste disposal problem? Do you purchase with that attitude in mind? Have you ever expressed your opinion to a manufacturer on such things as packaging, planned obsolescence and other similar problems?

Choice of transportation affects the environment. What kind of transporation do you use? How much does it contribute to air pollution? What do its by-products, such as roads, railways, service sations, air fields and garages contribute to the decline of open space? What alternative methods do you have? Have you ever taken an active position toward resolving the private vs mass-transit problems?

You affect the environment as a voter. How do the candidates of your choice rate as environmentally perceptive and concerned citizens? Will they offer and support progams that will achieve and maintain a quality environment for all the people? A conservation platform is often stated by candidates for national office, do you request a statement of position on local environmental problems from candidates for local office?

To many of these and similar questions, answers that would assure achievement and maintenance of a high quality environment will have to be made almost second nature to us -- instilled as part

of our concept of "norm." Other questions will require conscious rational thought, much of it soul-searching and agonizing. Students of today must become equipped, as never before, with the knowledge and skills to deal with such environmental questions and many, many more. The solutions chosen will determine the course of the human species.

PURPOSE

The prime purpose is to give administrators, curriculum people, teachers and intrested citizens a statement of what might be considered essential in developing environmentally literate citizens who will be able to make decisions and choices as producers, consumers, voters and recreationalists that will sustain a liveable environment.

The following statements are descriptive of the kind of behaviour to be expected from an environmentally literate individual. They are essentially a statement of goals. The following sections indicate the conceptual inputs and processes suggested as necessary to develop a person who will behave accordingly.

Environmental illiterates are rather obvious by their behaviour -- they are the polluters; the over-consumers; the careless destroyers; the inhumane.

But how do we recognize the environmentally literate? How do they behave? The following description is of a paragon of virtue that probably does not exist, most likely will never exist. It is only a goal to be strived for.

An environmentally literate citizen:

1. Should be able to recognize environmental problems when they arise. This means he must acquire a basic understanding of the fundamental interrelationships among men and the bio-geochemical environments. Without such understanding he cannot perceive potential breakdowns in the system resulting from technologies and population density-dependent factors -- breakdowns that reduce the quality of life which could ultimately affect the ability of the biosphere to sustain life.

2. Must think before acting, examining as many facets of an environmental issue as possible before taking his action position.

3. Rejects short-term gains when they threaten long-range benefits. He recognizes that environmental problems are easier to prevent or arrest than to reverse.

4. Takes action to correct environmental imbalances through

such approaches as:

a. altering his consumer and work practices to make them ecologically sound.
b. expressing his concerns and opinions to appropriate officials.
c. suggesting and/or writing and supporting appropriate legislation
d. initiating and/or participating in group action and encouraging others to identify and take action on environmental issues
e. supporting appropriate organizations with time and/or money

5. Continues to gather information about environmental issues throughout his life, recognizing that knowledge and skills once acquired cannot be expected to serve a lifetime in our rapidly changing world: yesterday's solutions may not fit today's problems.

6. Is humane--that is, recognizing the ecological interrelationships of all living things, he extends the concepts of humaneness to all life, striving for reduction to a minimum of cruelty and callousness to all living things.

7. Must treat public property and the private property of others with the same respect and stewardship he extends to his own most revered property.

8. Has a keen sense of stewardship, maintaining and improving the ability of his home area to sustain and enhance the quality of life. He recognizes a need to use the environment fully but also an obligation to pass it on to the future with as little damage and as much improvement as possible.

9. Demonstrates a willingness to curtail some individual privileges and even rights to certain resources for the long-range public good.

10. Consciously limits the size of the family he engenders consistent with the limited resources of the biosphere.

11. Works to maintain diversity in the total environment -- both natural and man-made.

12. Is continually examining and re-examining the values of his culture in terms of new knowledge about man and his resources. He then seeks to change values and assumptions that are creating man-environment interactions disruptive to optimum development of human potential and the integrity of the cosystem.

INPUT

To achieve the desired output of environmental literacy, students have to grapple with certain basic ideas. They must ingest them, digest them, and incorporate them into the very fabric of everyday thought and action. Concepts that are relevant to environmental literacy can be found in every part of the school curriculum, Environmental education is essentially interdisciplinary. It is an integrating factor that can give relevancy to other wise rather abstract disciplines.

However, the major core of environmental concepts come from the areas generally classified as natural sciences, social sciences and humanities. Our concern is with the minimun inputs for environmental literacy thus the understandings listed below are limited to these core ares. This list is certainly not complete, but it provides a rough outline of ideas that can be spread throughout at least 13 years of schooling.

NATURAL SCIENCE AREAS

1. Life is a special organization of matter activited by energy.
2. Living things exchange matter and energy with the environment.

3. Matter is for all practicable purposes finite and is re-circulated continously by such bio-geochemical interactions as:
   a. the carbon-oxygen cycle
   b. the nitrogen cycle
   c. the rock cycle
   d. the water cycle
4. Matter exists in various states and may be transformed from one state to another.
5. The ultimate source of the energy used by living systems is the stellar system, primarily the sum.
6. There are different forms of energy.
7. Energy changes from one form to another.
8. Energy may be transformed but it is neither created nor destroyed.
9. Energy changes may be either helpful or harmful to living things depending upon the situation and the amount.
10. Energy is passed unidirectionally through living systems and is rapidly dissipated according to the laws of the thermodynamics.
11. Plants use energy from the sun to make food.
12. Some of the energy stored in plant-made food is distributed to animals by way of food chains and food webs.
13. Environment is the sum of the conditions and influences which affect the life and development of living things.

14. There are characteristic environments each with its characteristic life forms.
15. All individuals have certain basic needs such as air, food, water, and a suitable climate.

SOCIAL SCIENCE AREAS

1. Man is an animal.
2. Man is a social animal with a generalized preference for high density living.
3. Man is a group-territorial animal.
4. Man generally functions with a dominance hierarchial social system.
5. Man is an animal with an extended sense of past and future time.
6. Man is an integral part of the natural environment and is constantly affecting it.
7. Man is the only animal that can successfully alter its environment on a massive scale.
8. Man can foresee many of the consequences of his management of his environment.
9. Human needs and desires are generally greater than the supply of natural resources available to meet them.
10. Nothing of material nature is a resource for man until man has a use for it or attaches value to it.

11. Man uses the elements and products of the land and water in his work of producing for others and himself.
12. Some people are producers of materials and equipment. All people are consumers of the materials and equipment.
13. The economy of a region depends upon the utilization of its resources and technology.
14. Man modifies the environment through technology.

HUMANITIES-LANGUAGE AND ARTS

1. Men vary culturally in their relative sense of time-past, present and future.
2. The average Western man's limited concept of future seriously impairs the development and implementation of long range environmental planning.
3. Men have developed many belief systems to help explain environmental mysteries. These often shape the nature of his interactions with the environment.
4. Effective planning relies on a strong sense of future-time.
5. Men vary widely in the breadth of their perception of environment.
6. Man's perception of his environment is limited by the nature of his sensory receiving structures.
7. A person's perception of the environment is largely conditioned by the culture in which he is raised.

8. An individual's perception of environment determines in large measure the ways in which he will relate to it.
9. Our perception of environment is in part shaped by the works of writers, painters, sculptors and other artists.
10. Artists record those aspects of the environment which to them have meaning; thus the art of a people is an indication of their response to their environment.
11. Words are attached to units of experience and places are named in every society.
12. Language imposes meaning and orientation and is necessary to the synthesis of ideas and man's control of his environment.
13. Ideas are models of realities built upon selected aspects of experience.
14. Ideas vary widely in their degree of full representation of reality.
15. Technology determines what is possible, not what ought to be.

PROCESS

The ways by which the previously stated understandings are communicated to students will be many. This is healthy. There are, however, some processes to keep in mind as being perhaps more useful than others in effective development of environmentally literate citizens.

A. Each student should be involved in rich and varied direct experiences with the environment. This is particularly important in the primary grades but should continue throughout the school years. Increasingly, the developing student should be helped to expand his perception of environment and to seek meaning from his experiences.

B. Each student should be encouraged to express environmental experiences through scientific and/or artistic means.

C. Each student should be stimulated to identify environmental problems and explore them.

D. Each student must be provided with ample opportunity to develop skills in group communication, activity and co-operation.

E. Each student must be exposed to strategies and opportunities for each value analysis and formation.

F. Each student needs to be continually challenged to expand his sense of time and sense of space.

G. Opportunities must continually be provided for development and practice of individual responsibility for environments.

H. Teachers and other responsible adults must demonstrate continually that learning is a continuing life-long process.

I. Education must be demonstrated to be relevant to day to day living.

J. Time must be given to exploring the ramifications of a wide variety of activities, to instill the habit of looking for the consequences of acting before doing.

K. Inquiry method with its emphasis on problem identification, multiple working hypothesis formation, data gathering and conclusion forming should be widely utilized in all appropriate areas.

In addition to the concepts and processes which have previously been sated, it is necessary to focus attention on some broader organizing concepts. These have been cryptically stated or implied earlier in this paper but need some amplification here.

To begin with, it is essential to broaden a child's perceptual abilities and skills at all levels. He must not only look but see; he must hear as well as listen. He must, in short, be trained to broaden the scope of awareness to the massive bombardments of sensory stimuli constantly reaching us all. He must seek meaning from experience while at the same time,

broadening the range of his experiences.

Environmental education will have to put greater emphasis on understanding of less commonly considered senses (such as space perception) and their implications. There must be a growing understanding that in addition to the aesthetics of space and form we must study the ways in which we experience psychologically comfortable and uncomfortable reactions to various spatial arrangements. These vary somewhat from culture to culture and are largely communicated and transmitted from generation to generation in non-verbal ways, most often at early ages. These spatial perceptions are subject to change through education. Our spatial perceptions have much to do with how we perceive other aspects of environment and help determine a number of our environmental values.

Time perception is also basic to environmental education. The breadth of the time spectrum of individuals is largely a function of culture and also has a maturation component. For many centuries, Western culture could not conceive of time reaching into the past for more than about 4000 years. On a practical level, past-time could only be conceived in terms of one's lifetime. Modern science, particularly geology, is slowly broadening the time-past spectrum for more and more people. It also helps imply a greater spectral range for time-future.

Envisioning the true perspective of environmental problems requires a broad time-past spectrum, planning for solution of environmental problems an equally broadened time-future spectrum. The average American time-future span of about 20 years is inadequate for dealing with 100+ year solutions. Expanding the individual's time spectrum perception is a basic challenge at all grade levels.

Related in many ways to the time spectrum are the siamese twin concepts of Change and Continuity. Change may be the only constant. We must learn to live with it and adapt to it although this is very difficult for many people. However, change implies continuity. Change is from one condition to another. The past and present give clues to the future. Rate of change is important. For living things, rate of adaptability (indeed itself a change) to change in environmental conditions is crucial. It governs continuity and discontinuity.

Perception of relationships and interrelationships must also be thematic in environmental education. Ability to perceive these is maturational and a definite skill based on practice. Related to this is perception of causality. Without such perceptual development, environmental literacy is not possible for problem identification: ability to examine the long range consequences of given actions depend upon them.

These themes, of course, are to be found pertinent to many areas of the curriculum and are not the special province of environmental education. However, without them basic environmental education must remain superficial.

Without these perceptual skills the individual cannot internalize the foregoing concepts and incorporate them into his belief or value system. Without a sound value system his behaviours toward environment beomce only parts of games; he acts in ways he believes will gain approval of the peers he happens to be with at the moment or to achieve identification with what he conceives as a desirable group.

Man has needs and desires. Both are supplied by the environment. Man often confuses desires and needs abuses the environment so that its ability to provide either or both is impaired for many people.

All men have a right to a quality environment. Vast numbers of people in both under and over developed countries are deprived of this right. Lack of education is in large measure responsible for this.

To even being to achieve improvement in attaining this basic human right, effective environmental education is a necessity.

Adapted from the Curriculum Overview for Developing Environmentally Literate Citizens. Developed by Charles E. Roth for the Liberty Council of Schools in co-operation with the Massachusetts Audubon Society.